solplan review

the independent newsletter of energy efficient building practice

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June-July 1989

Inside . . . .

New construction techniques mean that houses built today are much tighter. Use of high capacity exhaust fans means that significant pressure differences can be induced between indoors and outdoors. This can be very dangerous to the occupants.

Generally, we want houses to operate at neutral conditions. Providing pressure relief to a building is not as simple as it seems. We present work done by Mark Lawton. The issues are reviewed and the factors that must be considered in make-up air supply systems are described.

Draft-free construction techniques have been heavily promoted as an important component of quality construction. Yet there have been nagging doubts about the durability of some of the materials used, and of the techniques themselves. Recent studies have reviewed these performance tests of a group of houses over a period of time. The findings suggest that durability may not be an issue. We present findings of two of these studies.

Ventilation systems are a key part of new homes, but are they being designed and installed to do a proper job? We review a Winnipeg study that looked at installation and commissioning practices of mechanical systems.

Other items include a look at fibreglass batt insulation specifications, quality control in new high performance windows, mould growth potential in HRV's, and a variety of news briefs.

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Richard Kadulski

Make-Up Air

From the Publisher

Truth in Advertising. When you buy products or services, you expect they will meet the advertised specifications. If there is a problem, you expect the supplier to make good on his promises. If not, you try to get satisfaction or claim for damages through negotiation or the courts.

If you as a builder or consultant don't deliver the product you have promised, your customers will come after you. You know that you have to deliver what you promise.

So why do we let our politicians get away with lies and deceptions? Too strong? Just cast your mind back to the last election. Remember the promises? How many did they actually intend to deliver?

Don't think this is commentary that's out of place in a technical publication. During the election campaign the politicians were shopping for our votes, selling themselves. They should be expected to at least try and live up to the intent of their promises.

What is disturbing is the degree of cynicism on the part of politicians in recent years. They say one thing, and do the exact opposite (and we just let them get away with it).

The list is long. One small example. We are told that the government is committed to environmentally sensitive development. At the same time they are cutting back on already modest support for conservation and renewable energy activity, which is the direction for the long term. Only $8.5 million will be saved from the closure of EMR's CREO offices that were providing information and support services for conservation and alternatives. But they continue to support the oil industry with billions of dollars (like it or not, the oil industry is part of our problem). The discredited, uneconomical nuclear industry is still being given massive hand-outs.

Is that how we want to have things run?

Richard Kadulski
Publisher

Your next issue of SOLPLAN REVIEW may be a week or two late, as your editor has declared that this is the year for an official holiday. He will try to soak up some of the midnight sun in Scandinavia, and perhaps try to find out what is really happening there in the building industry (that is, if they haven't all taken holidays). We expect the next issue to get into the mail mid-September, so if you notice a gap in the delivery schedule, don't panic. We're not going out of business.

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Make-up Air Supply

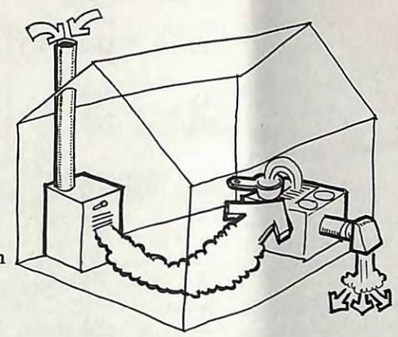
The development of new materials and building practices has led the construction of tighter, draft-free houses. The trend to using more high capacity exhaust fans in the tighter house can create high pressure differences between indoors and outdoors.

Where pressure imbalances are likely to happen, make-up air provision must be made. Technically, make-up air provides an "easy passage" for the entrance of air into a house to replace air exhausted from a house.
Restricting the inlet flow will increase the indoor/outdoor pressure difference required to create the replacement flow.

Why be concerned about these pressure differences? Hazards that can be associated with these higher pressure differences include:

1) Negative pressures can overcome the venting forces used to expel exhaust products from fuel-fired equipment. Spillage or backdrafting of combustion appliances (furnaces, hot water tanks, and fireplaces) is much more common than previously thought.
2) If there is no easy entry path for uncontaminated air (from the outside), replacement air may enter through contaminated areas. For example, soil gases (including radon) can be sucked into the house.
3) If ventilation in the house relies only on the exhaust devices, the rate of air change could be reduced as negative pressures restrict fan flow.

Historically, it has been assumed that make-up air would enter through the leaks and cracks naturally occurring in the building envelope. However, with the construction of tighter houses in recent years the quality of leakage paths have been



restricted. As a result, there are high indoor/outdoor pressure differences are happening.

Codes for fuel-burning equipment (gas, oil or solid fuel) require the provision of, or at least the consideration of, combustion sir supplies. However, these are sized to only supply the air needs of the appliance. These are always treated as stand alone units and do not consider the effect of any other exhausting appliance that may be present in the home.

There is a growing recognition, if not regulated as yet, that it is necessary to limit the suction forces in houses especially when there are likely to be exterior contaminants such as radon.

The CSA standard for residential ventilation systems (CSA F326.1 - Solplan Review No. 26) identifies a concern for balanced conditions. Unfortunately, ventilation in houses is not yet well addressed by current building codes.

The National Building Code of Canada requires that a house must have a mechanical venting system capable of providing 0.5 air changes per hour. It does not require that the system actually by used. Nor is it very clear what sort of pressure limits should be maintained.

A make-up air system must be sized to suit the house. A packaged system must be suitable to cover a significant portion of the housing market. Anything less than 80 or 100 cfm would restrict itself to a small segment of new housing. A make-up air system that could deal with 250 cfm would cover all but the most unusual housing configurations.

The ideal make-up air system would allow, or force, air to enter the structure at a rate that would maintain the house indoor/outdoor pressure differential at a predetermined level generally as close to neutral as practical. The fresh air entering the house should be distributed where most needed, to avoid pockets of pressure imbalances (a closed, reasonably airtight furnace room could develop some rather unhealthy pressure imbalances relative to the remainder of the house). The system should operate as desired under all weather conditions.

Requirements for an effective make-up air system.

Pressure control capacity.

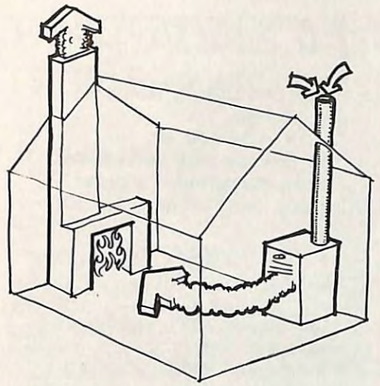
There is much evidence that the venting performance of naturally aspirating combustion appliances is affected by small negative pressures in the house. Negative pressure differences as small as 5 pascals can lead to some exposure to combustion spillage hazards, (especially when starting against a cold flue).

Appliances that use a fan to provide a forced or induced draft should, theoretically, have a higher pressure tolerance. However, it is now becoming clear that even for these a significant level of spillage occurs at negative pressures as low as 10 or 15 pascals.

Open fireplaces are of special concern. They are susceptible to

TABLE 1: TYPICAL AIRFLOW REQUIREMENTS (cfm)

	Operating at -5 Pa		Operating at -10 Pa	
	Small House (8800 ft³)	Large House (26500 ft³)	Small House (8800 ft³)	Large House (26500 ft³)
EXHAUST DEVICES				
Fans @0.5 ACH/HR	148	222	148	222
Largest common exhaust	265	265	265	265
(Downdraft cook top)				
FURNACES				
Natural Aspirating Gas	64	106	64	106
Induced Draft Gas	25	25	25	25
Condensing Gas	17	17	17	17
Conventional Oil	159	159	159	159
Condensing Oil	21	21	21	21
DOMESTIC HOT WATER HEATER				
Conventional Gas	21	21	21	21
Induced Draft Gas	21	21	21	21
Oil	159	159	159	159
WOOD BURNING APPLIANCES				
Open Fireplace	318	318	318	318
(Fireplace With Doors and No Combustion Air)				
(Fireplace With Doors And Combustion Air)				
Non-Air Tight Wood Stove	106	106	106	106
Air Tight Wood Stove	36	36	36	36
MAKE-UP AIR FLOW THROUGH THE ENVELOPE				
Tight House (1.0 ACH)	- 21	- 74	- 42	-127
Conventional House (2.5 ACH)	- 74	-201	-106	-328
AIR FLOW REQUIRED THROUGH MAKE-UP AIR SUPPLY				
Very Tight Houses				
gas heating, no fireplace	127	148	191	222
gas heating, no fireplace, grill fan	244	191	307	265
gas heating, open fireplace	445	466	508	540
- from the fireplace perspective	212	275	508	540
gas heating, fireplace, grill fan	561	517	625	582
oil heating & DHW, no fireplace	127	148	424	413
oil heating, open fireplace	445	466	582	572
electric heat, open fireplace	127	148	424	413
TIGHT CONVENTIONAL HOUSES				
gas heating, no fireplace	74	21	127	21
gas heating, no fireplace, grill fan	191	64	244	64
gas heating, open fireplace	392	339	445	339
- from the fireplace perspective	159	148	445	339
gas heating, fireplace, grill fan	508	381	561	381
oil heating & DHW, no fireplace	74	21	360	212
oil heating, open fireplace	392	339	519	371
electric heat, open fireplace	74	21	360	212



combustion product spillage at low firing rates and, when operating at high firing rates, can become major exhausting devices creating negative pressures that can influence other appliances in the house. Even fireplaces that are approved for mobile home use (the most stringent standard) are only tested at a pressure of 17.5 pascals and a significant level of spillage is allowed under the certification test. There are few fireplaces of any sort which operate with no spillage when negative pressures are much above 15 pascals.

Minor spillage on an occasional basis many not be a reason to panic, but sustained exposure to combustion products, especially if undetected, is not to healthy.

What is a "tolerable" level of spillage? Two factors must be taken into account:

1) The total amount and type of contaminants contained in the exhaust products and
2) is the spillage likely to happen when it may not be noticed (i.e. when occupants are sleeping?) Spillage from automatically operating appliances is of concern because this can happen when occupants are asleep.

It could be argued that spillage that may happen as a result of voluntary activities requiring the active participation of the homeowners (i.e. when they are awake) may be considered to be less of an issue.

Open fireplaces, must also be treated with a similarly stringent standard because of the relatively hazardous nature of their combustion products and the relative ease with which they can spill in an unattended dying fire situation. 0 to 5 pascal pressure standards should be applied to these devices.

Make up Air Capacity

The make-up air system must be sized to balance any exhaust flows from the house and must account for whatever can be supplied through the house envelope at the "tolerable" pressure. The stack effect will create a certain level of negative pressure during the winter but the mechanisms which create stack effect also improve chimney performance.

It is interesting to note how little flow actually penetrates the house envelope at very low pressures. Table 1 shows the calculated estimates of inward flow of air leakage through the building envelope.

Tight houses are not unusual in Canada. Houses with airtightness test results of less than 2.5 air changes per hour are not unusual. Depending on the volume of the house, a 5 pascal pressure difference would only create a 60 to 200 cfm air flow. In a very tight house, such as an R-2000 house, this could be reduced to 20 to 80 cfm. This is much less than the exhaust capacity in most houses.

Tempering Incoming Air

By its very nature, make-up air is cold outdoor air being brought into the house. Minimum distribution temperatures to occupied rooms should be at least 17°C if delivered through floor gills and 13°C if delivered through wall or ceiling grills. If comfort issues are not dealt with, the occupants will shut off all openings to restrict airflows causing drafts, and thus defeat the objective of the make-up air.

All Weather Performance

Aside from comfort issues, weather protection can be evaluated on two bases:

1) how does weather affect the normal operation of the device;
2) how likely is the device to fail due to weather effects?

Make-up Air Components

The key components of a make-up air system are:

- *an air passage through the building envelope*
- *a driving force for air movement*
- *a flow controller*
- *a control activator*
- *a temperature control element*

Sizing inlets for the required flow obviously depends on the driving force that is available to bring air into the house. This is especially relevant for passive duct systems, as the only driving force is the pressure difference (that we are trying to minimize).

Table 2 shows calculated flow rates for passive make-up air ducts assuming an equivalent length of 66 ft. (duct hood, a limited amount of ducting and one or two 90° elbows). Even an 8" duct can only provide 100 to 120 cfm at a 5 pascal pressure difference. This flow is at the very low end of the range that we would consider appropriate for broadly applicable make-up air systems.

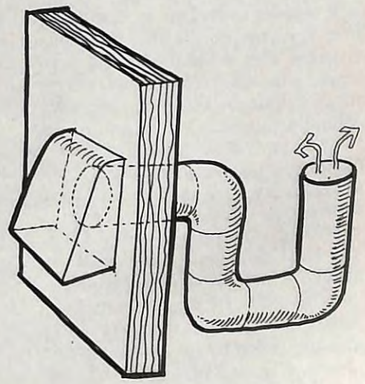


TABLE 2: PASSIVE AIRFLOW THROUGH DUCT (66 ft. equivalent length)
(CFM)

Duct Size (inches)	*Pressure Difference (pascals)*					
	5	*10*	*15*	*20*	*25*	*50*
3	<10	10	15	19	21	29
4	16	23	29	38	42	63
5	31	46	59	67	80	106
6	53	74	95	114	127	180
7	85	106	148	169	191	275
8	116	159	212	254	286	381
9	169	233	296	318	381	529
10	212	296	381	445	487	699

These are calculated flow rates for passive make-up air ducts assuming an equivalent length of 66 feet (a duct hood, a limited amount of duct and one or two 90° elbows).

It is obvious that a tight house with a large exhaust appliance such as a downdraft cook top is going to require a very large opening. If a mechanical force is not applied to drive the make-up air, then a very large opening will be needed. Any guess what's going to happen when the first cold spell comes along?

Many of the devices that are being marketed as make-up air inlets are clearly undersized and most of them don't show any advantage over a standard exterior duct hood in any case.

Obviously, some kind of driving force must be provided for make-up air entry. This could be done by a separate fan designed to ensure adequate flow at whatever pressure regime you need.

An independent supply fan gives you higher driving forces and smaller envelope penetrations but one is still confronted with the same control problems. How do you detect when you need make-up air and when you don't? A number of manufacturers have flow control devices including barometric damper, dampers which are controlled by furnace temperature, and electric dampers which require some kind of outside signal to tell them when to activate.

Some of the barometric dampers have been tested. The results indicated they don't work at the very low pressure levels that we are concerned with. The lowest pressure that activates dampers is about 20 pascals.

Electric dampers need signals to tell them when make-up air is required. Most commonly, they are interlocked with furnace operation so that the damper opens anytime the furnace is required. That is fine if all you are worried about is the furnace. But when you consider the domestic hot water heater, fireplaces or any other fan in the house, a fully integrated system would require a series of parallel controls and associated wiring running throughout the house. This could get expensive! There seems to be a real need for a single controller which can sense the need for make-up air and react accordingly.

This article is excerpted from a paper presented at the EEBA 'Excellence in Housing '89 conference' Winnipeg, Man. written by Mark Lawton, a principal of Buchan, Lawton, Parent Ltd.

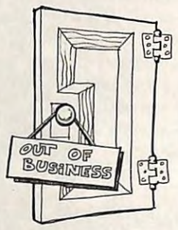
What are the properties of a good make-up air system?

** peak flow capacity should be 200 - 250 cfm.*
** a fan to drive the air.*
** the flow rate must be controlled (continuous operation at peak capacity would not be tolerable).*

Control strategies would include:

** interconnect with operation of combustion appliances*
** interconnect with large exhaust appliances*
** direct indoor/outdoor pressure control*
** make-up air pre-heating must be considered for most areas*
** heating control will be required.*

EBA Closes



The Board of Directors of the Energy Business Association in Seattle, has curtailed operations. EBA was a non-profit trade association focusing on energy conscious design and construction products and services.

The highest profile activity of the group were the *Housing for the 90's* conferences. Although qualitatively successful, the 1988 conference was a financial disaster. The resulting debt, with no prospects for offseting income meant the group had to close its doors.

The Board members also perceive that the public market has little current interest in energy conservation and the electric utilities in the US Pacific Northwest are unable to make the necessary decisions to effectively market their product vis-a-vis conservation.

(This organization should not be confused with EEBA or Energy Efficent Building Association which is still very much in business).

Draft-Free Construction
(1) Performance tests of tight homes over a 2 year period

Airtightness is a measure of the resistance to air leakage provided by the building envelope. For leakage to occur, holes must be present in the envelope along with a pressure differential to drive the flow. In residential construction pressure differentials are created by natural forces, such as wind and stack action, and by mechanical systems such as ventilation equipment, furnaces and other household appliances.

From a building science perspective, air leakage has several negative effects. The most obvious is increased energy consumption for both the heating and cooling loads of the structure. The second and perhaps most important effect is moisture movement into the envelope.

It is generally recognized that the prime mechanism for moisture transport is air exfiltration. This process can deposit significant quantities of moisture in the construction, usually concentrated in locations around the leakage sites. Water accumulations can accelerate rotting of wood components, insulation wetting and staining/destruction of interior surfaces.

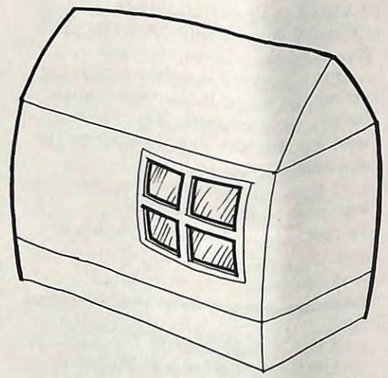
Air leakage can reduce comfort levels in a home if the infiltrating cold air is felt by the occupants. (This is why we prefer the term *draft-proof* construction rather than airtight).

Air infiltration can also degrade the quality of the indoor air if leakage occurs through an area where pollutants are present.

Thus building science, comfort and air quality considerations suggest that it is desirable to maximize the airtightness of a house. In practice, of course, air leakage cannot be eliminated but only controlled within defined limits. The National Building Code of Canada does not yet contain any quantitative requirements for residential airtightness.

The primary mechanism used to control air leakage through building envelopes is the air barrier which may consist of a single material or an assembly of materials. The main requirements for air barriers are generally defined as:

- low permeability to air flow
- structural strength to withstand the pressure loads
- continuity to reduce leakage
- sufficiently durable to last the life of the building
- rigid enough to provide pressure equalization behind exterior cladding



In new residential construction, polyethylene is the most commonly used material. Joints in the poly may be sealed with caulking or simply stapled in place. In most applications, it is also used as the vapour barrier.

A second system which has gained acceptance is the Airtight Drywall Approach (ADA) which relies on the drywall to function as the air barrier with paint or poly as the vapour barrier. Leakage at joints between major envelope components is controlled through the use of strategically located gaskets.

Airtightness tests

Tests were performed over two years on 20 new houses as part of the Flair Homes Energy Demo/CHBA Flair Mark XIV project in Winnipeg. The houses had similar floor plans and were constructed by the same builder. Polyethylene was used as the air/vapour barrier in 6 of the houses while 14 used the Airtight Drywall Approach (ADA).

Both systems met the airtightness requirements of the R-2000 Program. The tightest structures were the double wall houses. No significant or permanent change in airtightness was observed for any of the houses after the two year monitoring period. Variations which did occur were judged to be due to normal house behaviour.

DRAFT-FREE CONSTRUCTION WHAT'S IN A NAME?

We use the term **airtight** *construction regularly, but what image does it leave the home buyer? How often do you hear concerns about the air inside? will it get stuffy? can you open the windows?*

Instead of stressing airtightness (which is what is required for proper construction) we should be stressing the consequences of airtight construction. The average person can understand a **draft-free** *environment. It's what we all strive for.*

Draft-free *construction explains our objectives, tells homeowners what they will get without frightening them. Why don't we insist on calling it* **draft-free?**

Each house was tested with a blower door two to four times a year. Measured airtightness levels ranged from 0.43 to 1.78 ACH at 50 Pascals.

The tightest houses were the four built with double wall construction, where the air/vapour barrier is sandwiched between the two walls. The average was 0.849 ACH when first tested and 0.905 ACH after two years.

The ADA houses had an average 1.227 ACH at the beginning and 1.277 ACH after two years.

The other homes using poly were 1.148 ACH at the beginning and 1.149 ACH after two years.

Houses with similar air barrier systems performed in a similar way. In other words, there was little change.

The use of stucco as an exterior wall finish (common on the Prairies) was found to produce a noticeable improvement in airtightness for the ADA houses. It was not observed to have as big an impact on airtightness of the double wall houses which used polyethylene as the air/vapour barrier.

Where was there air leakage?

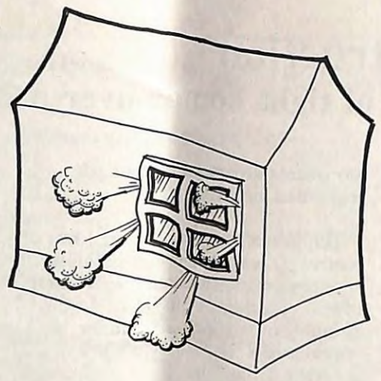
Only a few areas were consistently noted as sources.

In the ADA houses the electrical outlets on exterior walls, were consistent leakage sources. Commercially available semi-rigid "poly-pans" with foam gasket under the cover plate were used in these houses. Wire penetrations into the pan were caulked and reasonable care was taken to insure a tight fit between the pan and drywall. However, the flexibility of the pan material is believed to haver permitted leakage between the flange face and the drywall.

Window leakage was also frequently noted, particularly through joints in the frame, between the frame and casing and along the weatherstripping. The frequency of window source leakage has increased in the houses during the monitoring period indicating a gradual degradation of performance at this location.

Leakage was also noted along baseboards in the cantilevered bay windows in bedrooms in some houses.

Other leakage areas less frequently noted were service penetrations for ventilation ducts and, on the two



conventional houses, plumbing stacks and chimney penetrations.

There is considerable debate about which system is the most appropriate for Canadian conditions. The so called "poly approach" is usually viewed as a more traditional and hence better understood technique for new construction while the ADA approach is argued to be better able to withstand the pressure forces to which the air barrier will be exposed.

One reason for the debate over the air barrier design is the requirement for structural strength. The question is how large are the forces acting on the structure?

In residential construction, pressure loads due to stack effect seldom exceed 10 to 20 Pascals while loads due to the mechanical systems may be slightly larger. Wind action however, can generate pressures on an exposed building surface of over 1000 Pascals. If the air barrier is intended to withstand the entire pressure differential, then its structural design will be determined by the wind loads on the building.

One point that must be kept in mind is that airtightness is not a fixed performance characteristic of a structure but can fluctuate over time. However, major changes usually occur in the first year after construction.

PRESSURES ON RESIDENTIAL BUILDINGS

City	Design Pressures (pascals)
Winnipeg	880
Vancouver	1160
Edmonton	840
Toronto	1010
Halifax	1090
Coal Harbour NWT	2520
Minimum (several locations)	500

(These are the design pressures that the building envelope has to withstand)

The monitoring results lead to some interesting observations concerning the air barrier systems demonstrated in the project. First, it is clear that both the poly and ADA systems are capable of meeting the airtightness requirements of the R-2000 Standard. All of the systems met the Standard prior to the application of stucco which indicates they could also have met it if other, more permeable cladding systems had been used.

None of the air barrier systems demonstrated any significant change in airtightness during the monitoring period once the stucco had been applied. Although the airtightness levels were observed to fluctuate, there was no systematic tendency to increase or decrease. The observed variations in airtightness for the project houses were small compared to the range of airtightness levels measured for new, conventional Canadian construction.

The observed variations in airtightness of the houses could have resulted from several factors including: swelling and shrinking of wood framing members, degradation of weatherstripping, differential movement of the foundation, and measurement error.

Stucco, which was used on three of the four walls of each house, was observed to have a significant effect on the airtightness of all but the double wall houses. The ADA houses, with or without the TYVEK air retarder, displayed significant reductions in their measured airtightness with the application of stucco while the double wall houses using poly did not exhibit equivalent reductions.

Draft-Free Construction
(2) How durable are polyethylene air/vapour barriers?

In general, the performance of builders tends to follow a characteristic pattern or learning curve. In the first few houses significant leakage will be found at certain locations (depending on the envelope systems). Once these major leakage areas are identified, the builder is usually able to reach the R-2000 airtightness requirement fairly consistently, only deviating when a new system or new subtrades are used or a "blunder" is made.

Houses which do not meet the R-2000 requirement usually fail because a few major "holes" have been left unsealed. One way for builders to reduce the cost of "airtight construction" may be through the use of a simple "leak detection system". Its purpose would be to identify significant leakage areas so they could be sealed.

The airtightness monitoring program described in this study has not observed any significant change or degradation in measured airtightness in 20 relatively airtight houses over a two year period. Although testing is continuing, the results to date indicate that there is a need to examine the structural requirements for residential air barrier systems.

This item outlines the findings noted in the Flair Homes Project Report No. 5: "Airtightness Performance of 20 Detached Houses Over a Two-Year Period" prepared by Gary Proskiw of Unies Ltd., For information or to obtain a copy, contact: EMR, Residential Energy Management Division, Ottawa, Ont. K1A 0E4

The R-2000 Program has taken a special interest in the performance of air/vapour barrier systems. One of the key program requirements is a tight, draft-free building envelope. Much effort has been put on reducing air leakage in homes.

Although this can be achieved with a variety of techniques, many R-2000 builders find the use of a poly vapour barrier to be the easiest, most effective technique for achieving airtightness.

Another method that is gaining recognition uses the airtight drywall approach (ADA). Both methods when combined with proper building practices have been successful in reducing envelope air leakage.

Polyethylene vapour barriers

Polyethylene is known to deteriorate when exposed to excessive heat or ultraviolet radiation from sunlight. Concern has been expressed that polyethylene air/vapour barriers degrade over time.

Examples of polyethylene degradation have been discovered occasionally, but usually this is only noted when a wall is opened. If it fails after the house is completed, you don't really know until the wall has been opened.

Other factors affecting the long term performance of polyethylene are its composition and production techniques. Poly specifically suited for the building industry is a low-profit item. Only recently has a product standard for polyethylene has been developed, but it only covers 6 mil poly.

Under the new CGSB standard, poly film that is manufactured for use as an air/vapour barrier must be:

1. stabilized against heat and ultraviolet light (sunlight);
2. packaged so that it is protected from direct exposure to sunlight;
3. made only from virgin resin;
4. of a minimum average thickness of 6 mil

Buchan, Lawton, Parent Ltd. analyzed available data on airtightness tests done on the same houses over a period of time. The object was to determine if the concern about polyethylene decay over time was justified.

Raw data was collected on 145 homes from a variety of sources. Data was used only if:

1. the fan tests were done on the same house by the same firm (to avoid any possible inconsistency in test methods);
2. the construction of the house was complete (if the tests were done before the house was completed, the difference in airtightness is not useful); and
3. the initial air change rate per hour (ACH) was less than 3.0 (if the leakage was greater the polyethylene was assumed not to be performing as an air barrier).

These houses considered included
34 Energy Efficient Homes in Ontario
15 homes in Sweden
5 homes in Montana
30 low energy homes in Saskatoon
22 R-2000 homes tested by Buchan, Lawton, Parent Ltd.
20 Flair EnerDemo Homes (including: 6 R-2000 Polyethylene and 14 R-2000 air tight drywall construction (ADA).

The data included houses which had been retested more than two times (as many as seven air tests were done on the 20 Flair homes within a two-year period).

The tests were done some time after construction was fully complete, in most cases more than three months after completion.

The 90 homes that met the criteria were separated into two groups: those with an initial air change rate of less than 1.5 ACH and those with an initial

ACH between 1.5 and 3.0. The initial ACH, the time in months between tests, and the difference in change between the first test and each subsequent test were looked at.

Homes were considered to have a significant loss of tightness if there was an increase in the air change rate of more than 0.3 ACH and if the change was more than a 20%.

Of the 42 homes with an initial ACH less than 1.5 only six homes had a significant loss of tightness under both criteria. Of the 48 homes with an initial ACH between 1.5 and 3.0, only three homes met both criteria. This indicates that there is only a minor average change in airtightness.

Overall, the data examined indicated relatively minor changes in average airtightness (decreases of well under 10%). A relatively small proportion of houses actually showed an increase in airtightness.

It is not clear from the report if an analysis was made of the poly material used in these various studies. This is a factor to consider, as there have been some higher quality, durable poly materials on the market, especially in Scandinavia and in the USA.

Analysis was done to determine if there was a common pattern to the changes in test results over time. A sudden increase between two tests with little change before and after that increase, would be an indication of catastrophic, probably physical, damage to the air barrier of the building. A gradual increase in the air change test results would be evidence of a gradual degradation of the air sealing characteristics. No common pattern was detected in the group of houses for which multiple test data was collected, making the analysis inconclusive.

There is no indication that significant problems exist that would necessitate a change to current building practices.

These observations do not indicate that polyethylene degrades when used as an air barrier for residential buildings. However, the lack of negative evidence does not prove conclusively that problems will not develop over a period of a decade or more.

FUNCTIONS OF AN EFFECTIVE AIR BARRIER

it must be:
- impermeable
- continuous
- flexible
- able to withstand any loads placed upon it.

The air barrier must be flexible enough to adjust to any structural movement without allowing openings that may form.

Polyethylene vapour barriers usually allow for some stretching and movement without the envelope being broken.

In the ADA, the joints must be made of elastic gaskets or flexible caulking to allow for movement. Each system has a limit on the extent of movement it can allow.

Comparison of Airtightness Retesting Results prepared by Buchan, Lawton, Parent Ltd. for Energy Mines and Resources. Copies of the report can be obtained from
EMR, Energy Publications,
460 O'Connor St.,
Ottawa, Ont. K1S 5H3

Letter to the Editor

Sir,

In the February-March issue (Solplan Review No. 25) you ran an article titled "WOOD-ELECTRIC HEATING SYSTEMS". The systems illustrated are not safe due to the fire danger and the possibility of asphyxiation of the building occupants from flue gas leakage. For that reason they are prohibited by the B.C. Building Code.

Home made solid fuel burning furnace add-ons are difficult to make safe and for the average home owner or installer just about impossible to verify as safe. In this day and age of ULC/CSA standards with testing laboratories and certification of heating systems using heat sensors and measuring spillage to construct a system like that illustrated in your article is foolish.

There are ways of safely combining wood heat and electric furnaces. The best way is with a certified wood furnace add-on. This appliance is installed after (downstream of) the electric furnace. This way the super heated air does not pass through the fan and plenum of the furnace. If installation and clearances are to the manufacturer's tested guidelines the owner can be assured that he or she has a safe heating system.

Another safe wood electric installation is with the electric furnace in the basement or crawlspace and the space heater (wood stove) on the main floor. The return air grill is located at ceiling height in an interior wall in the warmest area of the dwelling.

Convection combined with circulation and distribution using the furnace fan on low speed will give a uniform temperature throughout the home. As the space heater is located in the positive pressure zone the danger of spillage is removed (if the house is ventilated properly with combustion and/or make-up air). The fire danger is also eliminated as a capture hood is not used and the return air grill is located at least 60" away from the space heater. (Return air grills should not be used in an alcove that has a heater installation.)

Last month I attended a course put on by the Canadian Wood Energy Institute. Their Wood Energy Technical Training program put on by WETT BC is excellent. They have certification courses for installer, sweeps, and inspectors. For more information you can contact CWEI (416) 445-6296.

Gary Backlund
Ladysmith, B.C.

P.S. You noted in your article on crawlspace ventilation that heated crawlspaces need not be vented. A warm moist crawlspace can cause problems and that's why the 1985 B.C. Building Code (9.18.3.1 and 9.18.3.5) requires ventilation unless the crawlspace is vented to a basement or used as a warm-air plenum. The code is being changed to prohibit the use of a crawlspace as a warm-air plenum.

You raise valid safety concerns about wood stove add-ons. The system described was engineered. It consists of a separate, free standing wood stove located close to a regular furnace. The ductwork is modified to include a capture hood to pick-up heat from the woodstove.

The original specs adhere to required clearances. It has not had any safety problems, but it was concerns about potential safety problems that led to the design and performance review that was summarized in our piece.

Use of any fuel fired appliance inside a building must be installed carefully, in accordance to codes and manufacturer's instructions to avoid any problems.

On the crawlspace ventilation issue, it is our contention that if a crawlspace is a heated space (i.e. insulated) it is no different than a basement. In such a case, there is no justification for requiring venting, as it will be warm, and presumably has been sealed off.

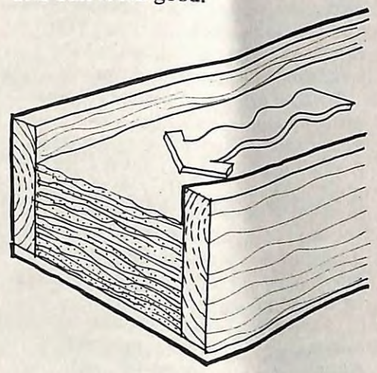
Although it may not necessarily be the most efficient way of doing it, a properly sealed, insulated crawlspace can be a warm-air plenum. There is no technical, building science rationale for changing this requirement.

The crawlspace is often used as a convenient space for heating ducts and services, so a warm space inside the heated envelope makes sense. R.K.

Q. When is 10" not 10"?
A. When it's a fibreglass insulation batt.

Who can you believe?

Two years ago, Fiberglas Canada Inc. introduced a new high density batt rated at R40 with a listed thickness of 10 3/8". The product is designed to fit between 2x12 wood joists, and provide a vent space above the insulation. Getting good insulation levels in vaulted ceilings (common on the West Coast) is difficult, which is why the R40 batt looks good.

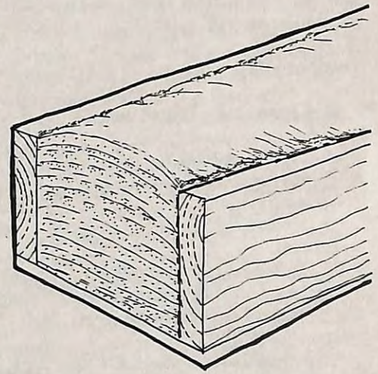


In our projects, we have been specifying the batt size where appropriate. Then we heard that the R40 batts are much thicker. Some municipal inspectors were insisting on extra strapping to increase the depth. The Fiberglas representative advised that there had been a problem with the insulation, and that batts were thicker than advertised, but that the situation was a manufacturing problem that had been rectified.

The issue has surfaced again. A renovation project has just been tendered, and the successful contractor indicated that his insulator can't get the insulation. But a check with the manufacturer indicates that the product is readily available.

At first I thought it was a case of contractor or supplier not wanting to stock a particular size. But the insulation contractor indicates he's had lots of problems. They've been measuring samples of the R40 batts at random and they've never been less than about 12" thick when unpackaged (they have measured batts as thick as 16").

He provided a copy of a letter from the branch manager for Fiberglas Canada who states:
R40 is manufactured to a nominal thickness of 10 3/8". To ensure that the stated R Value is always provided, 10 3/8" will normally be the absolute minimum recovered thickness of a batt. It is not unusual for the recovered thickness to be as great as 12". Technical characteristics of our manufacturing processes make it impossible to guarantee that recovered thickness will not exceed 10 3/8".



The specifications provided by the manufacturer are what every architect, specifier and contractor must rely on. It is most unfortunate when that information is incorrect. If there is a legitimate reason for varying the thickness of the product, then the manufacturer should spell out what the allowable tolerances are. This is critical, as other construction components have fixed dimensions, and building codes have specific requirements. The manufacturer must fully describe the product so that it can be used correctly.

Ventilation systems
design, installation and commissioning: how well is it done?

To provide improved indoor air quality in new homes mechanical ventilation is a must. Debate continues over how best to provide it. What types of systems are most appropriate? What will the cost impact be on the price of the home?

To try and provide some answers, the Flair Homes Energy Demo/CHBA Mark XIV Project in Winnipeg undertook to evaluate the performance of several residential mechanical systems, with special emphasis on ventilation systems.

Ventilation Systems

The systems looked at were:

** Combined Heat Recovery Ventilator (HRV)/forced air heating system*
** Dedicated HRV ventilation system*
** Dedicated HRV ventilation system with a heat pump HRV*
** Prototype exhaust-only heat pump HRV*
** Integrated heat pump HRV, space and DHW heater*

The mechanical systems were designed by UNIES Ltd. in accordance with standard industry (HRAI) design practices.

Most of the houses had high sidewall supply registers rather than conventional floor registers. This was done to provide better ventilation distribution and to reduce discomfort caused by cool drafts. Standard off-the-shelf HRV's were used.

The houses were completed in the spring of 1986. All system installations were done by a large mechanical contractor with several years of experience on a variety of residential mechanical system installations including HRV's in R-2000 houses. Additional on-site support and inspections were provided by the system designers.

The houses were left in a "contractor-delivered" state. Only the total ventilation supply and exhaust flow rates were measured and adjusted to their design values. One house was also zone-balanced to adjust the internal air distribution.

Tracer gas tests were performed to determine the actual air change rate experienced by the house due to the combined effects of mechanical ventilation and natural infiltration.

Detailed balancing exercises were carried out in seven of the houses. These were performed after the tracer gas testing had been completed. Test procedures varied slightly depending on the type of system, but typically consisted of measuring the branch and main duct flow rates in the system and then making the necessary adjustments to achieve the design flow rates.

In the case of forced air heating systems, only the total supply and exhaust rates were measured and adjusted.

Branch duct air flows were measured at the appropriate supply or exhaust grille.

What was found?

Combined HRV/Forced Air Heating

The most common type of ventilation system in R-2000 houses is the combined HRV/forced air heating system in which an HRV supplies outdoor air to the return air plenum of the furnace which in turn mixes and distributes the air throughout the house. Continuous operation of the furnace blower is required.

Two houses in the project had this type of system. Two features of the systems are: a) return air registers were used in each room to assist air circulation when interior doors were closed and b) all supply registers were mounted high on interior partition walls to minimize occupant discomfort. (This is not the standard practice for forced air systems)

The complete design of the heating and ventilation systems for one house took about 12 hours for an experienced designer. This included the HRV ductwork, supply and return systems and the high-sidewall supply ductwork.

These systems were installed and commissioned in accordance with recommended practice, and were able to achieve the design ventilation rates. Because of the high recirculation rates by the furnace blower, there was good air distribution throughout the house. However, it was noted that exhaust duct leakage in the basement provided a major portion of the basement ventilation.

Dedicated HRV ventilation systems

These are usually used with baseboard or radiant heating systems in R-2000 type housing. In the absence of forced air heating ductwork, the dedicated HRV ventilation system is designed to supply outdoor air to each zone of the house.

The time required for an experienced individual to design the dedicated HRV system was about 6 hours.

These systems did not achieve the desired distribution of ventilation air without zone balancing. Grille location and direction of throw had a strong impact on the mixing of ventilation air with the room air. Short circuiting of ventilation through open interior doors could take place.

Total ventilation rates were unaffected by to position of the interior doors. Dedicated HRV ventilation systems usually rely on under door air transfer, but there are practical limits to the amount of undercut possible due to increased noise transfer.

The balancing reports for three houses showed that too much air was being supplied to the basement while insufficient flows were reaching the main floor. With the basement supply grills closed, the system in one house was able to attain a good distribution.

It was noted that the basement received enough ventilation just by duct leakage, which was substantial in both the supply and exhaust ducts. As most of the ducts are located in the basement, the researchers suggested that duct leakage could provide ventilation air to the basement. (This is not the recommended practice!).

How bad was the leakage? 42% of the total flows in both supply and exhaust runs. In one house, taping an 8 foot section of duct between the HRV and flow measuring station resulted in 32 cfm of leakage being eliminated (20% of the total flow)!

The design of proper design for a low pressure with proper grille design is important.

Exhaust-Only Heat Pump/HRV Ventilation

As these houses did not have fireplaces or other open combustion appliances, 2 were equipped with prototype exhaust only heat pump heat recovery ventilation systems. They use four speed exhaust fans to provide variable ventilation capacity.

They are designed to depressurize the house and provide required ventilation requirements through the envelope leakage (utilizing the dynamic wall approach).

This type of system relies on a 'proper' distribution of envelope leakage to provide balanced and distributed infiltration into each zone.

The test results were not clear, but they do suggest that the system was not able to achieve the desired ventilation rates. The reason for this is because of leakage in ducts, cross leakage in the heat recovery module, and the air handler itself.

From the design and system layout this type of system is substantially different from conventional mechanical systems, and requires careful planning and integration to the overall structure. The location of doors relative to grilles is important, as poor layouts can short circuit air flows.

Another problems noted was with the nature of the equipment. It required considerable amount of homeowner input: the unit had 3 dials and 3 switches.

Good mechanical systems have to be designed to operate as automatically as possible, so that there is a minimum of occupant input required. Not all homeowners are techno freaks!

The equipment in these houses were prototypes, and following the tests the manufacturer replaced the units with updated units which resolved the manufacturing problems.

Observant readers may have guessed that the system desbribed is the Fiberglas Canada Habitair system.

How bad was the duct leakage? In one house, 42% of the total ventilation air flow in both supply and exhaust runs leaked out.

Integrated Heat Pump HRV Space and DHW Heating Systems

These systems combine several different components into one mechanical package. They used 2 speed circulation blower, with extra capacity provided by manually activated exhaust fans in the bathroom, kitchen and laundry.

This system used a Peach heat pump, which is no longer made. However, integrated mechanical systems will become more common, as new equipment is being developed. They offer the potential for efficient, simple systems. The lessons learned can be used in other situations.

Careful planning of the installations was found to be more critical than with conventional systems. The units themselves were large and heavy, requiring planning at the framing stage to manoeuvre them into place. As well, two large duct penetrations (8"x32") were needed, and had to be allowed for at the foundation construction stage.

As with other systems, uncontrolled air leakage from the unit case, and ducts was a major problem.

The blower unit must be isolated from the structure to avoid vibration and noise transmission problems which happened in this installations.

Ventilation rates could not be determined by the installer due to the method used in the HRV unit to introduce outdoor air with the recirculating house air. Installed in accordance with recommended practice, the total ventilation rate was adequate, although a large variation in flow rates was noted between the two houses.

Commentary

This study was done a couple of years ago, so it reflects the state of the art of the industry at the time. In areas where much R-2000 activity has taken place, the findings described are old news, as mechanical trades have become familair with the equipment. However, the observations made and lessons learned are still valid.

By their vary nature, some systems are harder to inspect and verify that they perform as intended. We shouldn't have to design systems just for the convenience of the inspector, but if they can't be inspected (whether by inspector or installer) how can we be sure that they are working the way they are supposed to?

One common item noted in all installations, regardless of mechanical system type, is that there is a lot of duct leakage. Poor installation practices can defeat the intent of the best system design.

This item outlines the findings noted in the Flair Homes Project Report No. 3: "Design, Installation and Commissioning of the Ventilation Systems" prepared by Gary Proskiw and E.G. Phillips of Unies Ltd., D.A. Figley of IRC/NRC, and D.R. Fisher of K.P. Engineering & Design. For information or to obtain a copy, contact: EMR, Residential Energy Management Division, Ottawa, Ont. K1A 0E4

Quality Control Issues
Problems with Low-E glass

Richard Kadulski

Glass is the most vulnerable component in the building envelope. It has been described as a thermal hole in the building envelope. However, we are seeing new types of glazing films, spacer bars, and total assemblies becoming available. Window R-values of 8 or more are no longer wild claims or dreams.

Recent developments in glazing technology and a better understanding of how heat flows in a window work suggest the idea that windows should be avoided to have an energy efficient building may soon be an idea out of the past.

The new products are more expensive, but with a larger market penetration and the longer production runs this should make costs competitive for the product. Low-e glazing is already becoming the standard product for some major quality manufacturers.

Unfortunately, we have noted a reluctance on the part of other suppliers to supply these improved products.

More troubling are the stories that are surfacing about the poor quality of product that is being supplied: glass with streaks, finger prints, or other imperfections. More disturbing are the stories about poor or no follow up: suppliers reluctant to replace or correct defective material.

Only last fall I specified Low-e as a minimum on one project. To my dismay, some suppliers were trying to talk the owner out of using the better product!

In another case with which I was involved, the low-e glass was delivered with scratches, uneven coating film (so that streaking was evident) and finger prints. The uneven coating was easily noticed. The reflections disrupted the city views (it was a spectacular view that was being obscured at night - in the words of the owner, they "didn't pay to have the night view obscured by a mirror"). Unfortunately, the supplier was not keen on correcting the problems, and the owner was so dissatisfied that he insisted on replacing all the low-e glass with regular glass.

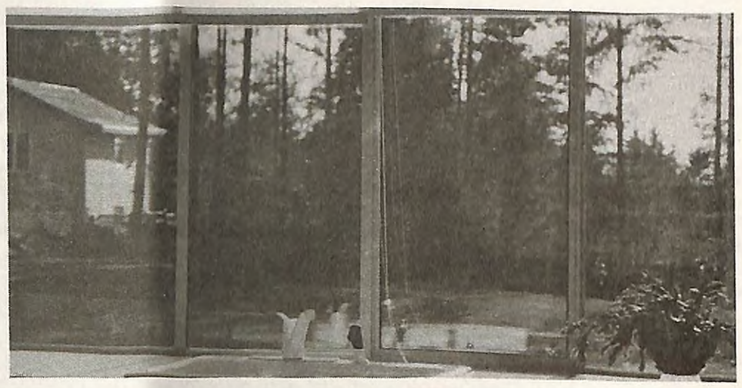


Fig. A The left pane has been replaced with clear double glazing. The right 3 panes are the original low-e glass.

Another case that we have heard about is illustrated here. Some definition has been lost in the printing process, but the original photo (fig. A) very clearly shows a foggy image through the 3 units.

The owner did much research prior to building the house, and decided that low-e glazing was the correct thing to use. Unfortunately, as these photos show, the product delivered was totally inadequate.

Regrettably, the supplier has not been keen to resolve the matter. It is obvious that the glazing is going to have to be replaced. It looks like the whole issue is going to end up in court.

Fig. B A close up of the glass. The streaks and fogginess are not a reflection!

Doubtless, a couple of individual examples shouldn't tarnish the whole industry. However, we have heard of other stories but they are anecdotal. As the saying goes, where there's smoke, there's fire. We just hope that these examples aren't the tip of the iceberg, with more to come.

Regrettably, the problems seem to be nothing more than a classic case of poor quality control. Soft coat low-e requires careful handling, and cannot be washed in the regular manner.

The concern we have is that we are looking at a new product that promises to revolutionize the building stock in this country. Although energy conservation may have a low profile with the public, the long life span of buildings means that any improvements made now will have long term consequences. The new window technology not only deals with energy issues, it also improves the comfort of the house as well as having beneficial consequences on the environment.

Improvements to our housing stock must be made if we are serious about the long term performance of housing. We're already using as much insulation as is feasible. Now it's the glazing industry's turn.

The Quality Plus program in B.C. is pushing hard to see more improved glazing used (especially in electrically heated homes).

So far it seems that the industry is hesitant to get involved, discouraging people from using improved products. Not delivering or following up orders properly does not give the industry a good image, nor put confidence in the industry and its products.

The argument that the everyone is too busy in a buoyant market just won't cut it. The best time to introduce new products is precisely when there's a lot of work, and money is (relatively) abundant.

Is the industry up to it? Can it deliver? So far, the jury is still out.

Odds 'N Ends

Mould Growth in HRV's

Heating, ventilating and air conditioning systems may be sources of fungal contamination. Concerns that HRV's (an important component in new housing) may be potential sources of moulds and fungi led to a study by Ortech International (formerly the Ontario Research Foundation).

Components from 4 different HRV units were studied, including the insulation materials, filters and heat exchange cores. Each was inoculated with controlled fungal mixture, and exposed to warm moist conditions for 28 days.

The results? No mould growth was observed on any of the metal or plastic parts. The only components that were susceptible were disposable paper or cardboard air filters. These showed a moderate mould growth.

If there is contamination in the ventilation system, it would happen in older units. Swab samples from 74 HRV units installed in houses across Canada were taken and analyzed. The species of microbes were found to be those commonly found in typical Canadian houses.

Only 3 were found to have potentially harmful mould growth. Follow up investigation was done.

In one case, the problem was accumulated debris outside, at the air supply inlet. In the second case, there was unusual fungal growth in the ducts downstream of an in-duct humidifier and in the exhaust grille in the kitchen. In the third case the kitchen exhaust duct was contaminated, but this was not affecting the supply air or air quality of the house.

The study showed that in each of these cases the problem originated from poor maintenance of vents, exhaust ducts and humidifiers. The residential HRV thus is not a source of fungi inside the house, and does not pose a health hazard. However, it is important that systems be properly maintained.

HRV Market Share

Ever wonder how many HRV's are being installed? Is it just R-2000 and similar houses that use them? A recent survey of ventilation systems in use in Canadian housing suggests that 10% of all new houses are now fit with HRV's.

If that's the case, and not just manufacturer's overstating their shipments, it means that significant progress has been made in improving the quality of Canadian housing stock.

Garbage problems?

You think you've got problems getting rid of your construction garbage? We've heard that in some areas of New England builder's waste disposal costs for a single family house can easily run to $1500 (that's US $)!

GRILL TALK with dave & the whispersisters
As news of the new B.C. HRAI code course sweeps the ventilation community...
We Swedish grills will be treated the way we deserve!
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from all of us at
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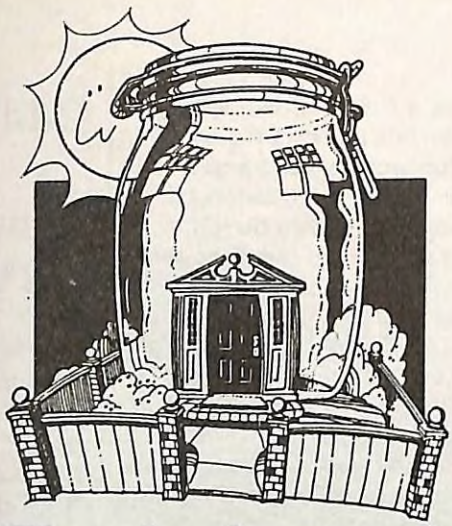
Advanced House - Progress (?)

The Advanced House demonstration project to build a state-of-the art, super energy efficient house has had its ups and downs (the project was initiated in 1982).

The goal is to build and monitor a house designed to have an energy budget less than 50% of an equivalent R-2000 house, reduce peak electrical power consumption to 10 KW, maximize passive solar gains, and demonstrate an integrated mechanical system.

It is now under construction (by the Fram Building Group) with funding by Energy Mines Resources Canada, the Ontario Ministry of Energy and Ontario Hydro.

At press time we learned that the local building authorities have had reservations about some of the components being used and put a stop work order. This is how progress is made?



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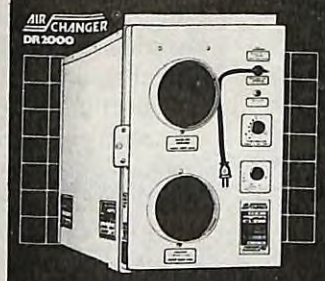

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